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DECLARATION

The undersigned, Olaf Bexhoeft, hereby states that he is well acquainted with both the English and German languages and that the attached is a true translation to the best of his knowledge and ability of the German text of PCT/DE02/03958, filed 10/19/2002 and published 08/07/2003 under No. WO 03/064763 A1, and of forty-eight (48) claims amended under Article 19, PCT.

The undersigned further declares that the above statement is true; and further, that this statement was made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or document or any patent resulting therefrom.

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Specification

Method and Device for Reducing Vibrations in Rotating Components

The invention relates to a method and device for reducing vibrations in rotating components in accordance with the preambles of claims 1, 5, 12, 30 or 36.

A method and a device for the active suppression of vibrations is known from EP 0 956 950 A1, wherein compensating forces are applied to rollers, for example, as a function of measured forces. The frequency for applying the force is continuously determined, inter alia from the actual rpm, the phase and amplitude of the measurements from the path signals of a spacing sensor.

EP 0 331 870 A2 discloses an arrangement for the seating of cylinders, wherein journals of a cylinder are seated in two bearings arranged side-by-side in the axial direction of the cylinder. The bearings can be individually moved vertically in respect to the axis of rotation by means of pressure medium cylinders, for example for compensating bending.

A method for compensating vibrations of rotating components is disclosed in WO 01/50035 A1, wherein an actuator is arranged in the area of a surface of the rotating components and, in the course of activation as a function of the angle of rotation position of the rotating components, counteracts the vibration by means of a force component in the axial direction.

JP 4-236819 A describes a system for reducing bending vibrations in a shaft, wherein a rotating disk connected with the shaft is charged with forces by means of piezo elements via electromagnets as a function of measured values.

In its discussion of the prior art, WO 97/03832 A1 shows various ways by which bending or bending vibrations at impression cylinders can be statically reduced. As a dynamic solution it proposes to measure occurring vibrations and to use these measured values for regulating and controlling actuators.

DE 199 30 600 A1 discloses a method for the reduction of undesirable bending vibrations in a rotating component of a coating device by means of an actuator, wherein the actuator acts on a bearing journal.

The object of the invention is based on creating a method and a device for reducing vibrations in rotating components.

In accordance with the invention, this object is attained by means of the characteristics of claims 1, 5, 12, 30 or 36.

The advantages to be gained by means of the invention lie in particular in that a possibility for effectively reducing vibration was created with little outlay. The reduction of the vibrations can take place actively during the production run.

The correlation of the countermeasures to be taken with the angle of rotation position is of particular advantage, because by means of this many of the periodically repeated obstructions, such as for example asymmetries, surface errors, grooves and other interruptions of the surface, balance errors, can be addressed, for example.

The method makes it possible to counteract an excitation, or vibration, at the moment it arises, without a negative effect having been initially detected and processed, before a suitable step is taken. The course of the step relating to the angle of rotation, as well as its size, is predicted in a preferred embodiment.

The continuous measurement and further processing of data regarding vibrations or deformations can be omitted.

Particularly in a case where two or more cylinders are working together - such as, for example, for so-called "rubber-against-rubber printing" in printing units - and where one or several of the cylinders show obstructions at their surfaces or balance errors, the method already counteracts the generation of vibrations and thus aids in the prevention of "bumping up" of the entire system.

Exemplary embodiments of the invention are represented in the drawings and will be described in greater detail in what follows. Shown are in:

Fig. 1, a first exemplary embodiment of the method and the device for reducing vibrations,

Fig. 2, exemplary courses of the dependency of a signal for an actuator from an angle of rotation position of a cylinder (a: discrete, b: continuous),

Fig. 3, a second exemplary embodiment of the method and the device,

Fig. 4, an embodiment variation of the second exemplary embodiment,

Fig. 5, exemplary embodiments a), b) of the method and the device at a printing unit with four cylinders.

A rotating component 01, for example a cylinder 01 or a roller 01 of a processing machine, in particular of a rotary printing press, for example for web-shaped goods, is rotatably seated between two lateral frames 02, 03. For this purpose the cylinder 01 has journals 07, 08, for example at the front ends, which are seated in bearings 04, 06. The cylinder 01 has a length of 1350 to 1550 mm, for example, and a diameter of 450 to 700 mm,

in particular of 500 to 600 mm, for example. The cylinder 01 has a ratio between the length L01 and the diameter D01 of 6 to 12, in particular between 7 and 11, for example.

Undesirable vibrations of the cylinder 01, in particular bending vibrations, can occur during rotation, which can be caused, for example, by balance errors, asymmetry, or by rolling off on a further rotating component - possibly also being asymmetrical -. For example, one or more grooves 09 axially extending on the surface for fastening non-represented dressings, or joints at the ends of dressings, constitute periodically occurring obstructions 09, which excite the undesirable vibrations in the cylinder 01. It is common to the mentioned obstructions 09 that they occur in an identical, or at least similar, size and order of magnitude in connection with a known stationary operating situation. A snapshot of the cylinder 01, for example at the reversing point of the vibration, is represented in dashed lines, greatly exaggerated, in Fig. 1.

At least one actuator 10, 11, by means of which the vibrations can be counteracted, is assigned to the cylinder 01 for reducing the undesirable vibrations. For this purpose the actuator 10, 11 is charged with signals S, whose sequence and/or whose strength is predicted as a function of an angle of rotation position Phi of the rotating component. The angle of rotation position Phi of the cylinder 01 is known, for example, either from a machine control device, not represented, or from an angle-regulated electric motor, not represented, which drives the cylinder 01, or is determined by means of a sensor at the cylinder 01.

Fig. 2 shows representations by way of example of the course and strength of the signals S, which are for example stored

or predicted in a control or memory device 12 (or in a circuit) as a function of the angle of rotation position Phi. For example, in case of the presence of one obstruction 09, the period length represented, which is periodically repeated, can be one revolution (for example 2 pi, or 360°) or, in case of several, symmetrically arranged comparable obstructions, can be a whole number portion of a revolution (for example 180°, 120°, etc.). In the course of a stationary operating situation, the actuator is charged during periodic repetitions with the predicted sequence, or strength, of the signal S. The dependency S(Phi) can be stored in the form of discrete pulses (a), or as a function (b) which continuously extends within a period. If charging takes place by means of a changeable force, it is advantageous that at least one journal 04, 06 of the rotating component 01, 18 is specifically charged with an appropriate force pulse at least one per revolution. The signal S is directly correlated with the angle of rotation position Phi. Different dependencies can be stored for different operating situations, such as for example different rpm ranges, different dressings or other values determining the characteristics. It is thus possible, for example in the vicinity of rpm of the resonance frequency of the excitation of the cylinder 01, to demand higher levels than in other areas. These dependencies can also be mathematically connected with each other, or can be generated in a different way. Thus, for approximately the same configurations the course can be identical, but the absolute strength can be correlated with the existing angular speed dPhi/dt in the form of an offset or spread.

In the exemplary embodiment in accordance with Fig. 1, respectively one actuator 10, 11 acts on respectively one of the journals 07, 08 in that a coupler 13, 14 encloses the journal 07,

08 via a bearing 16, 17, for example. In an advantageous embodiment, the coupler 13, 14 acts on a portion of the journals which protrudes past the bearing 04, 06 on the side of the latter which faces away from the cylinder 01. The course of the cylinder 01 and the journals 07, 08, represented in dashed lines, is now counteracted by means of the control device 12, in that the actuator 10, 11 applies a counterforce (positive or negative) to the journal at suitable angle of rotation positions Phi corresponding to signals S, or continuously in case of a continuous course. The signal contains the size and, if required, the direction of the counterforce to be applied by the actuator. The bearings 04, 06 constitute a nip of the journals 07, 08. A bending moment is introduced into the cylinder 01 via a portion of the journal 07, 08 representing a lever arm. In principle, one actuator 10, 11 can be sufficient for the cylinder 01, but the arrangement of two actuators 10, 11 each in the area of a journal 04, 06 is advantageous.

The actuator 10, 11 can be embodied as a piezo element 10, 11 in particular. Here, for example, the signal S controls the voltage from a voltage source, not represented, which is to be applied to the piezo element 10, 11. In place of the signal S it is also possible to supply the actuator directly with an appropriate voltage which, in this case, has already been made available by the control device 12. However, other installations, for example units based on magnetic or hydraulic force, can also be considered as actuators 10, 11.

The journal(s) 07, 08 of the cylinder 01 is or are specifically charged with an external force or a force pulse at least once per revolution of the cylinder 01, or undergo a change

in the externally applied specific force at least once per revolution.

The cylinder 01, for example in the form of a forme cylinder 01, acts together, for example, with a second rotating component 18, for example a second cylinder 18 such as, for example, a transfer cylinder 18, which can also have one or several axially extending obstructions 19 on its surface. However, it can also be designed without an obstruction 19. The triggering of the actuators 10, 11 now takes place, for example in the above mentioned manner, in such a way that the excitation of the vibration during the passage of the obstructions 09, 19 in particular is also damped. It is possible, for example, to apply an appropriate pulse to the journal 07, 08 via the signal S simultaneously with the passage. A great advantage of this operation is that the signal S, or the counterforce, is predicted, and therefore the counterforce or an actuating path can already be charged at the time of the excitation of a potential vibration. It is therefore not necessary to first measure a negative effect in order to initiate a suitable reaction.

For engagement or disengagement, or for varying the engagement, for example, the cylinders 01, 18 are preferably seated so they are variable in distance in respect to their axes of rotation in all examples. For this purpose at least one of the cylinders, for example the cylinder 01, is seated in the bearings 04, 06, for example embodied as eccentric bearings 04, 06. However, it can also be pivotably seated on levers, or guided in a linear guide device.

In a second exemplary embodiment (Fig. 3), the cylinder 01 is movably seated. The actuator 10, 11 acts, for example, on the bearing 04, 06 itself, which is embodied either to be movable in

the lateral frame 02, 03, or as an eccentric bearing (for example a three-ring or four-ring bearing), for example. By means of the actuator 10, 11, the cylinder 01 can be displaced in accordance with the signals S in its direction of movement, which substantially extends perpendicularly in respect to the axis of rotation of the cylinder 01. The movement has at least one component toward or away from a cylinder 18 acting together with it. The cylinder 01, for example as a forme cylinder 01, again works together, for example, with the second cylinder 18, which has no, one or several obstructions 19 on its surface. Triggering of the actuators 10, 11 takes place in the manner already explained in the first exemplary embodiment. The signal S can here contain information regarding the actuating path. In this way it is possible to effectively reduce an excitation during the passage of an obstruction and/or a "post vibration" of the cylinder, depending on the stored course of the signal S.

In an embodiment variation (Fig. 4), the actuators 10, 11 do not act directly on the cylinder 01, or its journal 07, 08, but on a stop 21 which limits the print-on position and which, depending on the status of the actuators 10, 11, permits the movement of the cylinder 01 within the limits of the actuating path predicted by the signal S. As a rule, in the print-on position the counter-stop 22 is placed against the stop 21, for example by an actuating device which twists the bearing 04, 06 with a force F, for example from a pressure medium cylinder, not represented. Thus, for example, during the passage of the obstruction 09, 19 relief can be provided by extending the stop 21 opposite the, and the excitation can be damped, or suppressed, in this way. Although the stop 21 is represented in connection with an eccentric bearing 04, 06 in the example, the method of

operation can be transferred in the same way to linear bearings, or bearings in pivotable levers.

As represented in Fig. 5, the employment of the described method of operation is of great advantage in printing units in which two pairs, respectively a forme cylinder 01 and a transfer cylinder 01, constitute a double print position for a web 23 passed between the transfer cylinders 18, which is to be processed, for example a web 23 of material to be imprinted. For example, all the cylinders 01, 18 have a circumference substantially corresponding to the length of a printed page, for example a newspaper page. For example, the length L01 of the barrels substantially corresponds to four times the width of four side-by-side arranged printed pages, for example newspaper width. In this case the cylinders 01 and/or 18 each have a groove 09 and/or 19 in the circumferential direction. However, the dimensions of the cylinders 01, 18 can also be such that it is possible to substantially arrange two linear pages in the circumferential direction, and six, or even eight page widths of a printed page, for example a newspaper page, in the linear direction. In this case two grooves 09 and/or 19, for example, can be arranged on the circumference of the cylinders 01 and/or 18.

As represented in Fig. 5 a), the fittings and the corresponding method of operation for one of the transfer cylinders 18 are already conceivable for effectively reducing the vibration in the area of the printing location. It is achieved that the excitations at least in the immediate vicinity of the web 23 to be imprinted are reduced. The phase of the obstructions 09, 19 is arranged in such a way that adjacent obstructions 09, 19 respectively roll off on each other.

An advantageous variation is shown in dashed lines in Fig. 5 a), wherein a forme cylinder 01 and a transfer cylinder 18 are operated by means of the appropriate method of operation. The embodiment with the actuator 10, 11 is preferably arranged on non-moved cylinders 01, 18.

If such obstructions 19 only exist on the forme cylinders 18, or if it is intended only to mainly reduce vibrations at the nip point between the forme cylinder 01 and transfer cylinder 18, it can be of advantage to only embody the two forme cylinders 18 with the described device, and to operate them by means of the mentioned method of operation (Fig. 5 b)). In this case it is possible to increase the counterforce at the forme cylinder 01, if required, in order to achieve parallel vibrations of the two cylinders 01, 18 acting together.

The arrangement on cylinders 01, 18 which need not be moved for engagement or disengagement is advantageous. However, it is also possible to equip only the two transfer cylinders 18, or all cylinders 01, 18, for example, with the device.

The solutions represented by means of a rubber-against-rubber printing unit are of course also applicable to printing units having a satellite cylinder, such as nine-cylinder or ten-cylinder printing unit.

The method of operation can also be applied to other processing machinery, wherein materials are intended to be accurately transported and/or processed by means of rotating components. The method of operation and the device are particularly advantageous if the rotating component 01 has an obstruction 09, 19 on its surface, a balance error based on the manufacture, or asymmetries, and/or works together with a second rotating body 18 having the mentioned properties.

The method of operation is as follows for the entire method:

First, a course of the undesirable vibration is determined for a defined configuration and or method of operation as a function of the angle of rotation position Phi. This can be provided by means of an additional, not represented sensor. In an advantageous embodiment the actuator 10, 11 is simultaneously used as a sensor, such as is possible, for example, in the case of a piezo element 10, 11.

Afterwards the course of a suitable counterforce, or an actuating path, which is a function of the angle of rotation position Phi, is determined by theoretical derivation with the aid of this function in such a way that the excitation itself and/or the vibration is effectively suppressed. In connection with this mode of operation the course of the vibrations themselves and/or the course of the determined counterforce, or the actuating path, are stored in the memory unit 12. In this way the course for the charging is predicted, and is independent to a large extent of measured values characterizing the vibration, instead in the end it only depends on the angle of rotation position Phi.

The determined course or strength can now be used for other modes of operation or configurations, provided the tolerances in the finished product, or the machine load, etc. permit this. During this comparative stationary operating situation the rotating component is charged in periodic repetitions with the obtained and predicted signals in accordance with the course of the determined counterforce or of the actuating path.

Otherwise the described action is performed in connection with different operating modes/configurations which are relevant to the actual use, and the respective dependency S(Phi), together

with the values characteristic of the operating mode/configuration, is stored. These dependencies S(Phi) can each be called up for the desired production and employed in the described manner for reducing the vibrations.

Thus, no continuous determination of actual values for characterizing the vibration are absolutely necessary for this method of operation. The method of operation acts rapidly and effectively, since the steps to be taken have already been predicted prior to the occurrence of the event (obstruction, vibration).

However, in an embodiment differing from the mentioned embodiment, the required amplitude and/or the phase (or the time) for applying the signal S (for the force or the force pulse or the chronological sequence to be charged) can take place as a function of a measured value which differs from the angle of rotation position Phi, for example an actual measurement of the path or the force at the cylinder 01 or its journal 04, 08. A mixed form of the methods can also be advantageous, wherein a base pattern and a base force on the basis of predicted data which are, for example, a function of the angle of position, are predicted, but a matching of strength and time is performed on the basis of other determined measured values. A system which is based on predicted signals S, or sequences, can also additionally be embodied to be self-learning and/or adaptive. In this case the system employs, on the one hand, the dependable and quick method of "control", namely before a measuring of the error, and only then a reaction occurs, while improvements of the algorithm, or the predicted signal S or sequences and/or strengths can yet be added. To this end the vibration, for example, is determined continuously or in defined

cycles by means of a measurement, and the stored parameters of the signals S are changed or complemented.

In an advantageous, because it is simple, embodiment, only an exterior excitation, i.e. a signal S or a force pulse (for example pulse-, ramp-, triangle- or delta-shaped) is impressed on the cylinder 01, 18, or the journals 04, 06 per revolution of each of the grooves arranged in the circumferential direction on the cylinder 01, 18. The vibration excited by means of this single force pulse (per groove and per revolution) forms a negative interference in respect to the vibration excited by the groove 09, 19 or an obstruction 09/19, if the relative angular position Phi between the groove excitation and the exterior force pulse has been suitably selected and the amplitude corresponds.

Since a path load is applied to the cylinders 01, 18 because of the rubber blankets being compressed, so that the cylinders 01, 18 bend, forces are introduced in an advantageous manner by means of additional bearings 16, 17, the support bearings 16, 17, which are seated outside of the bearings 04, which initiate counter-bending and in this way reduce the total bending. Since the path load briefly ceases (or is at least reduced) at the moment of the groove roll-over, the force applied by the outside-located bearings 16 on the journals 07, 08 should also cease (or be withdrawn) during this time window, since otherwise an excess vibration of the cylinder 01, 18 would result. By means of the controlled application of the bending forces to the journals 07, 08 during the groove roll-over it is possible to partially compensate the course of the vibration, the groove beat (i.e. the cessation of the bending moment exerted by the rubber blankets). In an advantageous embodiment the force control must take place within a time window which approximately corresponds to

the length of the groove roll-over. An alternative to this would be, as already mentioned in Fig. 2 b), the application of "counter vibrations" to the vibrations of the cylinder 01, 18 (fighting the symptoms). However, in this variation it is an advantage for the actuating system that the force control need not take place in such a highly dynamic manner, since the relevant time window is then determined by the vibration frequency of the cylinder 01, 18, and not by the short time of the roll-over.

An embodiment is advantageous, in particular in connection with cylinders 01, 18, whose ratio between the length L01 and the diameter D01 lies between 6 and 12, in particular between 7 and 11, in which a distance a in the axial direction of the journal 07, 08 from the center of the bearing 04, 06 to the center of the bearing 16, 17 is approximately 100 to 230 mm. For diameters (at least in the area of the application point of the bearings (16, 17)) of the journal 07, 08 of 55 to 65 mm, the distance preferably lies at 125 to 175 mm, while for diameters of 65 to 75 mm it lies, for example, between 150 and 230 mm. During the pulse, the journal 07, 08 is charged with a maximum force of, for example, 5 to 15 kN, in particular 7.5 to 11 kN. A movement of the support bearing 16, 17 advantageously lies between 25 and 100 μm, for diameters between 55 and 65 mm for example between 45 and 100 μm, in particular at approximately 60 μm, and for diameters between 65 and 75 mm for example at 25 to 80 μm.

The introduction of this force can now take place by means of two different variations: the force can be continuously applied during the length of rotation without an obstruction (no roll-over), and a counter-bending can be created in this way. This can take place via the actuator itself in a "positive" direction, or by means of an appropriate mechanical pre-stress. This force is

then briefly withdrawn or switched off during the time window of the roll-over which, in the first case can be achieved by a withdrawal at the actuator itself, and in the second case by a counter-action of the actuator against the pre-stress. Static bending is also reduced by this.

At a rotational speed of 20,000 rph (revolutions per hour), the time window for charging or withdrawing lies, for example, between 1.5 and 5.0 ms, in particular between 2.5 and 4.0 ms. At 90,000 rph, the time window lies between 0.3 and 1.0 ms, in particular between 0.6 to 0.8 ms. These time windows are related to widths of 1 to 3 mm of the groove opening on the surface in the circumferential direction. For double wide openings, the time windows are greater by a factor of two, for openings four times as wide approximately by a factor of four.

In an advantageous embodiment the actuator 10, 11, including the control or memory device 12 and the power supply, is embodied in such a way that a force of, for example, 7.5 to 11 kN can be applied to a path length of, for example, 25 to 100 μm. A piezo-electric system is preferred here, wherein the actuator 10, 11 is embodied as mentioned above as a piezo element 10, 11.

List of Reference Symbols

01	Rotating component, cylinder, forme cylinder
02	Lateral frame
03	Lateral frame
04	Bearing
05	-
06	Bearing
07	Journal
08	Journal
09	Obstruction, groove, disruption
10	Actuator, piezo element
11	Actuator, piezo element
12	Control device
13	Coupler
14	Coupler
15	-
16	Bearing
17	Bearing
18	Rotating component, cylinder, transfer cylinder
19	Obstruction, groove
20	-
21	Stop
22	Counter stop
23	Web, web to be imprinted
a	Distance (04, 16; 06, 18)
D01	Diameter (01)
L01	Length (01)

F	Force
S	Signal
Phi	Angle of rotation position
dPhi/dt	Angular speed